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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 4, 1996	Final, 6/1/96 - 11/30/96

4. TITLE AND SUBTITLE

The Application of LIBS to the Detection of Lead in Soil and Paint

5. FUNDING NUMBERS

DAAH04-96-C-0030

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

ARO 35747.1-GS-SBI

11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12a. DISTRIBUTION / AVAILABILITY STATEMENT

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12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report covers work conducted under a Phase I SBIR program to develop, fabricate, and deliver a Laser-Induced Breakdown Spectroscopy analyzer. This analyzer is capable of measuring the concentration of lead in contaminated soil and on painted surfaces.

Work during the contract involved defining design and performance parameters for the instrument, identifying and ordering component parts, and assembling and testing the analyzer. The analyzer was tested using a series of soil calibration standards containing known concentrations of lead. Quantifiable signals were obtained for soil containing 247 ppm lead. This compares well against the screeing action level for contaminated soils of 400 ppm. An operating and maintenance manual was written for the instrument.

Los Alamos National Laboratory provided technical support during the project. Phase II work will involve enhancing the performance of the instrument to include the ability to quantify a number of additional metals. The Phase II instrument will be evaluated at contaminated sites.

14. SUBJECT TERMS

15. NUMBER OF PAGES
22

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

Operations Manual for the ADA Technologies' Portable Pb in Paint / Pb in Soil LIBS Monitor

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1. Program Information

This instrument was developed by ADA Technologies, Inc. under a Phase I SBIR grant. contract, DAAH04-96-C-0030, for the DoD. For additional information about this instrument or other LIBS instruments under development by ADA Technologies, please contact:

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This first generation instrument is based largely on designs from Los Alamos National Laboratory, LANL. For further information on LIBS work being performed at LANL please contact:

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2. Safety

This unit is equipped with a laser and caution should be used at all times. Review the entire instruction manual, and become familiar with the design and operation of the unit prior to use. Be safe, not sorry.

3. Introduction to LIBS / Instrument Overview

This instrument is based on Laser Induced Breakdown Spectroscopy, LIBS. The following is an extremely brief description of the process and the advantages and disadvantages of the technology. In LIBS, a laser is focused on the sample of interest and pulsed. The laser is focused through a lens on to the sample. This focused energy vaporizes and excites the sample to a plasma state. The light generated by this plasma is collected and transmitted to a spectrograph via lenses and fiber optics. The light exiting the spectrograph is focused on to a CCD camera. The CCD is capable of quantifying the spectra and communicating with a computer. The spectra can then be analyzed using standard emission spectroscopy techniques. For this instrument two simple programs were developed which can be used to calibrate the instrument and analyze unknown samples. In addition, the software from the CCD camera manufacturer can be used for custom applications or research. The figure below is a representation of this LIBS instrument.

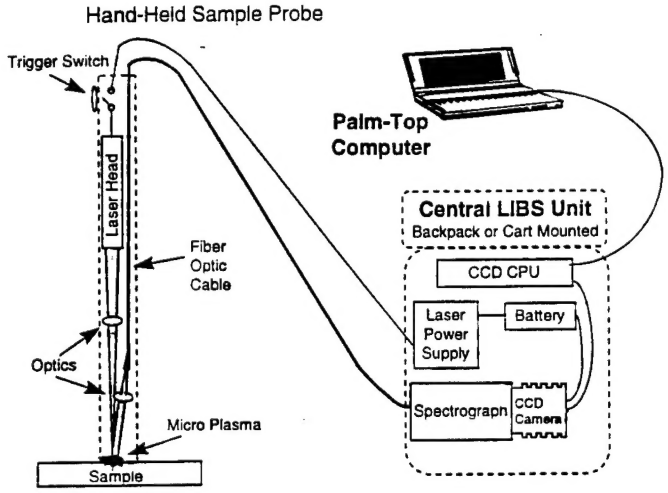

Figure 3.1 : LIBS Block Diagram

The advantages of LIBS are 1) that it can be used to analyze solids, liquids, gases and particulates, 2) that several spectral lines are available for each element (generally interferents can be avoided), 3) the same hardware can be used to measure several different elements, and finally 4) the instrumentation is simple.

Although LIBS has been used for analysis of solids, liquids, gases and particulates, this instrument is designed for the surfaces of solids. The size and power of the laser limit it to solids, and the focusing optics limit it to surfaces. These same components could be re-arranged to make measurements other than solid surfaces. These extensions will be evaluated in the Phase II program of this SBIR grant.

This Phase I instrument has been designed to target Pb in soils and Pb in Paint. Without any hardware modifications, this system can be used to detect elements other than Pb by a simple adjustment to the micrometer on the spectrograph and a few software menu

selections. The software developed for this instrument is limited to the analysis of one element at a time. The analysis wavelengths are selectable by the user (i.e. any element is possible). More general software which can be used for multi-element detection will be developed for future generations of this instrument. The current software will be more fully describe later in this manual.

The disadvantages of LIBS are 1) the extremely small size of the sample vaporized (in the ng range) leads to sample homogeneity questions, 2) the current lack of a general, universal, quantifiable calibration technique means that these instruments are best used as screening tools instead of an absolute ppm level measurement, and finally 3) calibration issues surrounding soil moisture.

These disadvantages pose no significant problem for this instrument because it is intended to be a field screening tool, and the screening action levels are well above the detection limits of this instrument even with the calibration issues. The small sample size is addressed by taking multiple samples at a given site in order to get a more representative sample. This is an important issue to keep in mind while operating this, or any other LIBS based instrument. More measurements lead to higher accuracy, and a reading which is more representative of the bulk soil sample.

4. Operation

This section of the manual describes the 1) the hardware components, 2) the software, and the 3) step-by-step operation of this LIBS-based Lead monitor.

4.1 Hardware

The following photographs show the major components of the ADA LIBS Pb monitor. The complete system is packaged in one enclosure. It is recommended that for field use that the instrument be place on a two wheel hand truck or on a cart for ease of handling. The unit weighs approximately 40 pounds including the 9 pound lead acid battery. Shock mounts or foam padding under the unit during transport is advisable for the continued alignment of the optics.

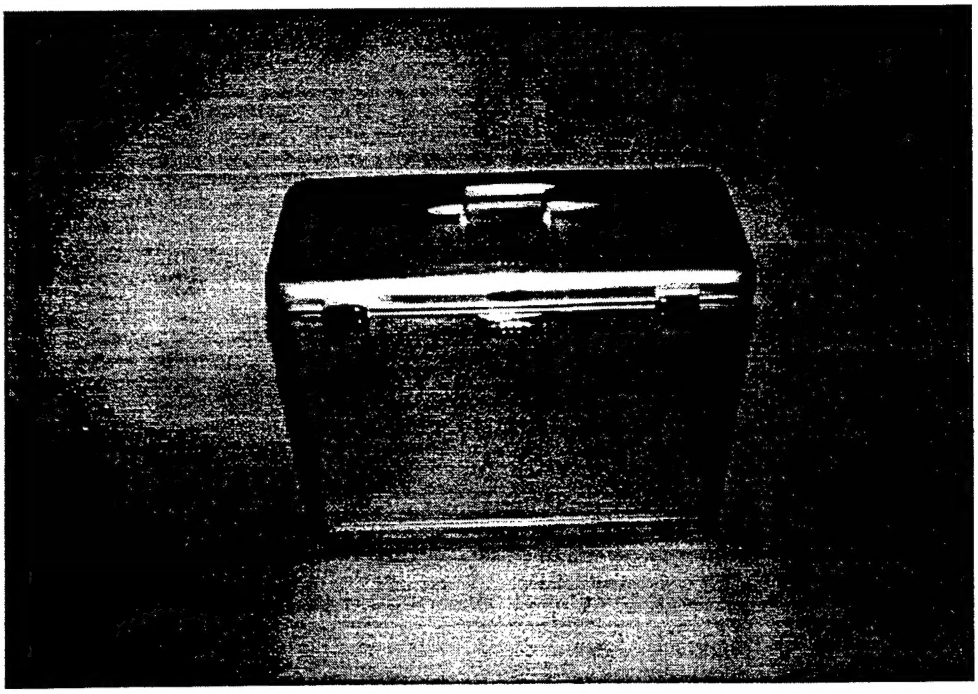

Figure 4.1 : ADA Technologies' Portable LIBS Instrument - Closed

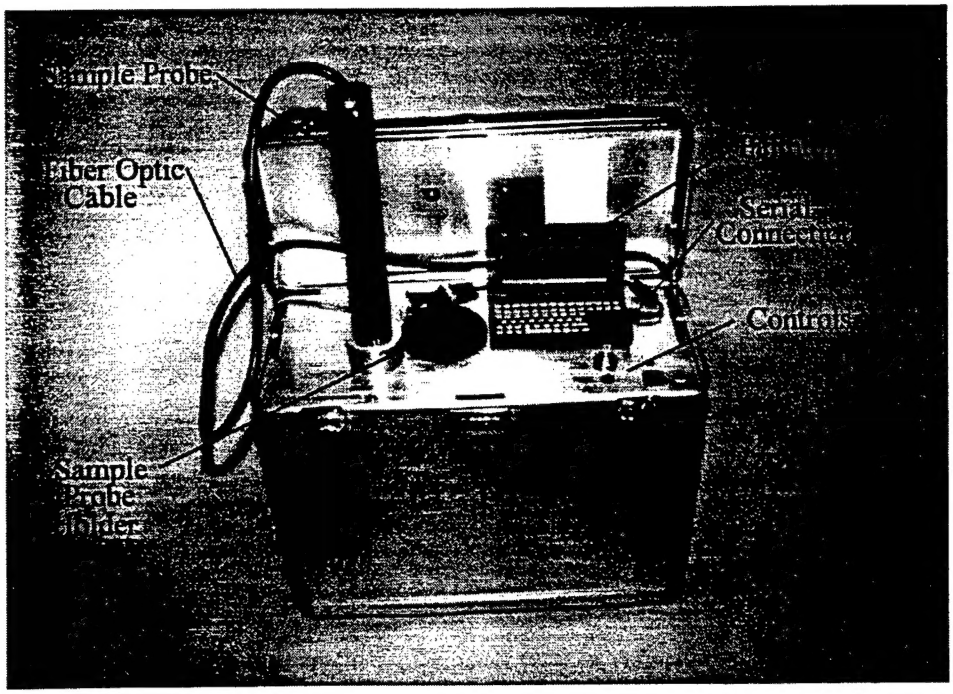

Figure 4.2 : ADA Technologies' Portable LIBS Enclosure - Open

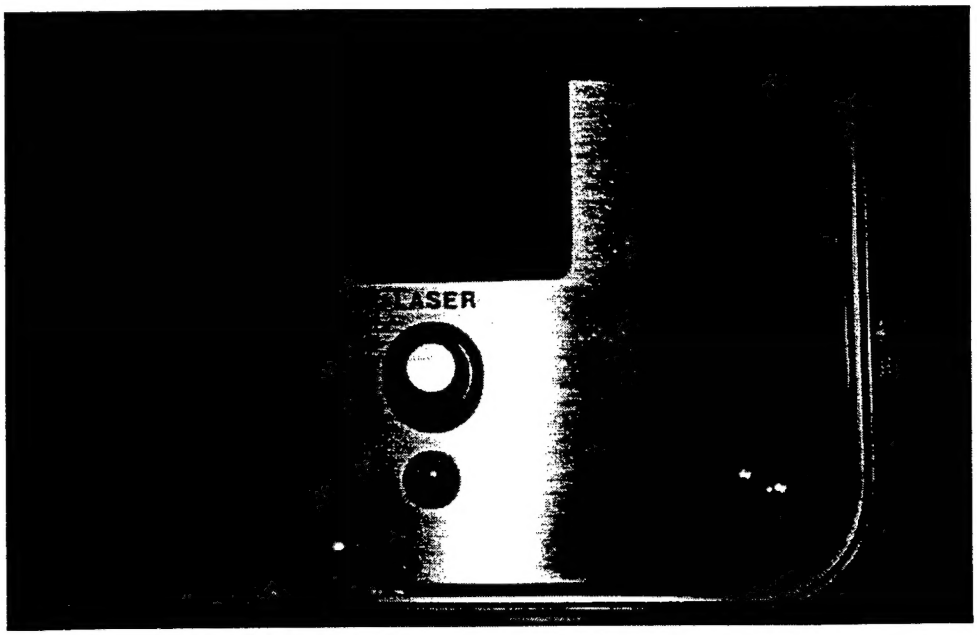

Figure 4.3 : Control Panel

Control Panel Description

Power Switch - The power switch turns on and off the power (12VDC) to the main unit, including the laser and the CCD. The Palmtop computer has its own power and on-off switch.

Power Indicator Light - The power indicator light is illuminated when the unit is turned on.

DC Adaptor Plug (12VDC) - The DC adaptor plug allows the unit to be powered through an adaptor to 110 AC. The adaptor has been included with this unit, and converts 110 AC to 12 VDC. Using the adaptor will save battery life. When the adaptor is plugged in, the battery is automatically disconnected.

Laser Power Adjustment Potentiometer - The laser power adjustment should be set to the minimum (lowest) setting that will fire the laser. Higher settings do not provide any better signal levels, and will lead to a decrease in life for the laser. At the time of fabrication, the potentiometer was set at 7.7. Determining the lowest setting necessary to fire the laser will be covered later in this manual.

Manual Trigger - The manual trigger can be used to manually fire the laser. This is helpful for alignment, and setting laser power. The laser is fired through the palmtop computer during normal operation, and the manual trigger does not need to be pressed.

HP 200LX Palmtop Computer - Any computer can control this LIBS instrument via a serial port. For reduced size, weight and cost a palmtop was selected.

Storage Holder for the Hand-held Probe - When the hand-held probe is not in use, it can be stored in the storage holder.

The following photograph shows the major components inside the instrument. These components consist of the following.

Components inside Enclosure

Lead Acid Battery - A 9 pound sealed 12VDC lead acid battery is used in this instrument.

CCD CPU - The CPU for the CCD recieves commands through the serial port of a computer, operates the CCD and performs on-board processing of the signals prior to delivering the collected spectra to the PC.

Spectrograph - Separtes the light collected from the plasma emission by wavelength and focuses that light on the CCD. This spectrograph has a 2400 l/mm, 250nm blaze angle grating and a 150 microm entrance slit..

Micrometer on the Spectrograph - Allows adjustment of the window of wavelengths being focused on the CCD. The width of the window is fixed by the grating, but the spectral region focused on the CCD can be changed by adjusting the micrometer. This makes it possible to use this instrument to measure elements other than lead.

CCD Camera - The CCD collects the spectra.

Laser Fire Controller - Prior to modification. the laser fire controller allowed the adjustment of laser power, and a fire switch.

Laser Power Supply - The laser power supply provides the power to the laser.

Fiber Optic Cable - The fiber optic cable in this unit transmits light from the plasma to thespectrograph.

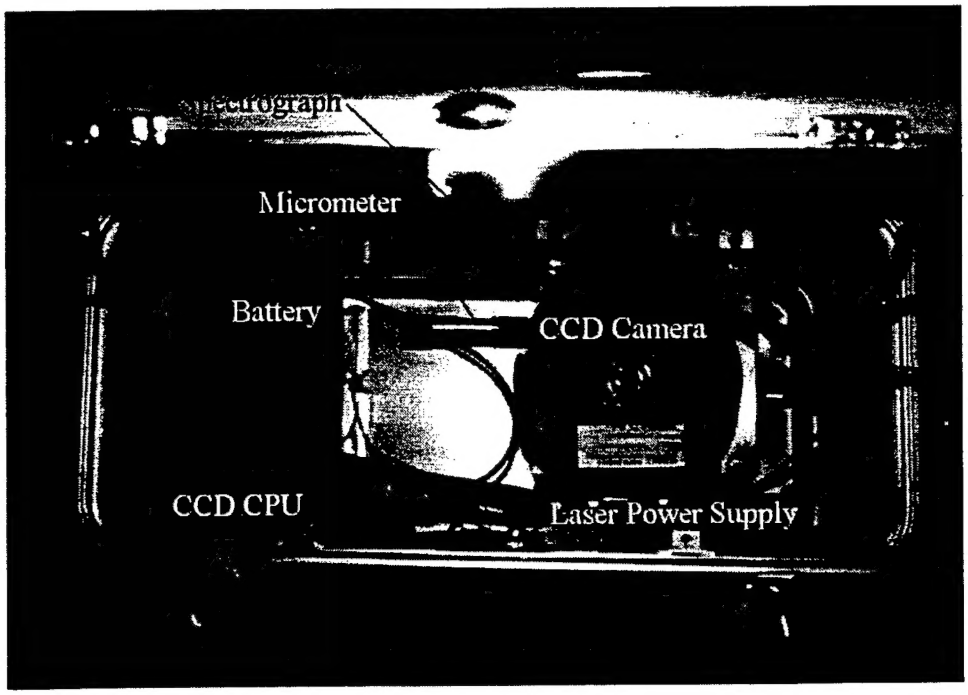

Figure 4.4 : Inside of LIBS Enclosure

The figures below show the inside and outside of the hand held sample probe. The laser is attached to the flashlamp. The laser is focused though the lens to a point which would be on the surface the hand-held probe is pressed against. The fiber optic is pointed at that point. A minor concern is that the open cavity at the bottom of the hand-held probe can build up vapor from previous laser pulses. The vapor can be re-excited by each laser blast and lead to false readings. Future instruments will have a purge fan in this chamber to prevent this vapor build up. The user should minimize the number of laser pulses between lifting the probe from the ground and venting this cavity. The user should also watch for debris build-up in this chamber. The final item to note on the hand-held sample probe is the set of mercury switches that prevent the laser from firing if the unit is not pointed straight down. This is a safety precaution. In future designs, this will be replaced with surface contact switches and photosensors to insure the unit is pressed against a surface in such a way that stray laser light will not exit the sample probe.

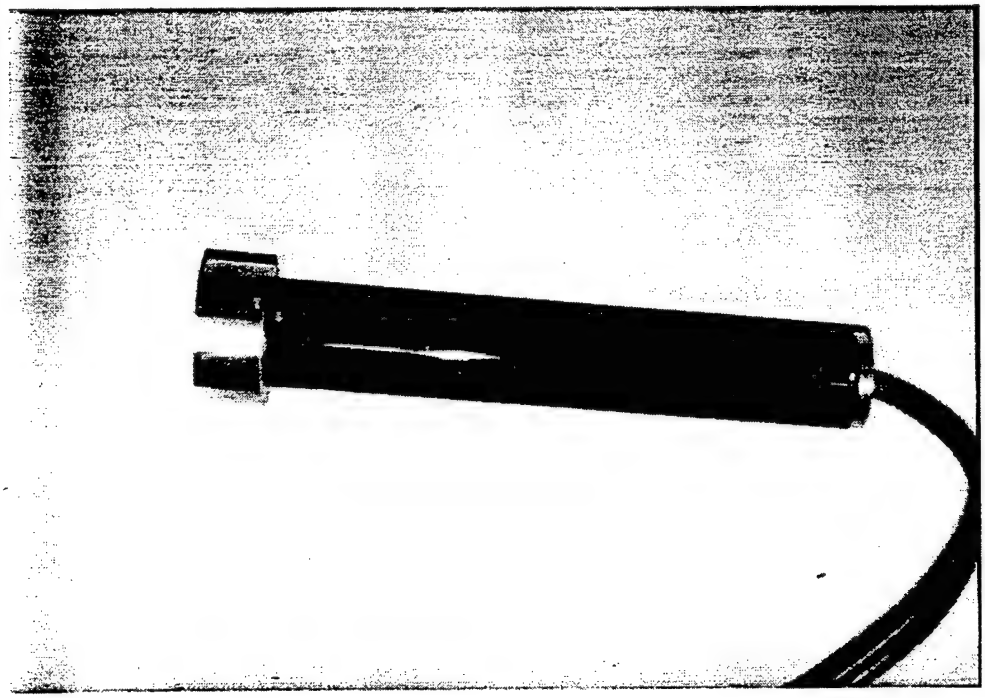

Figure 4.5 : Sample Probe

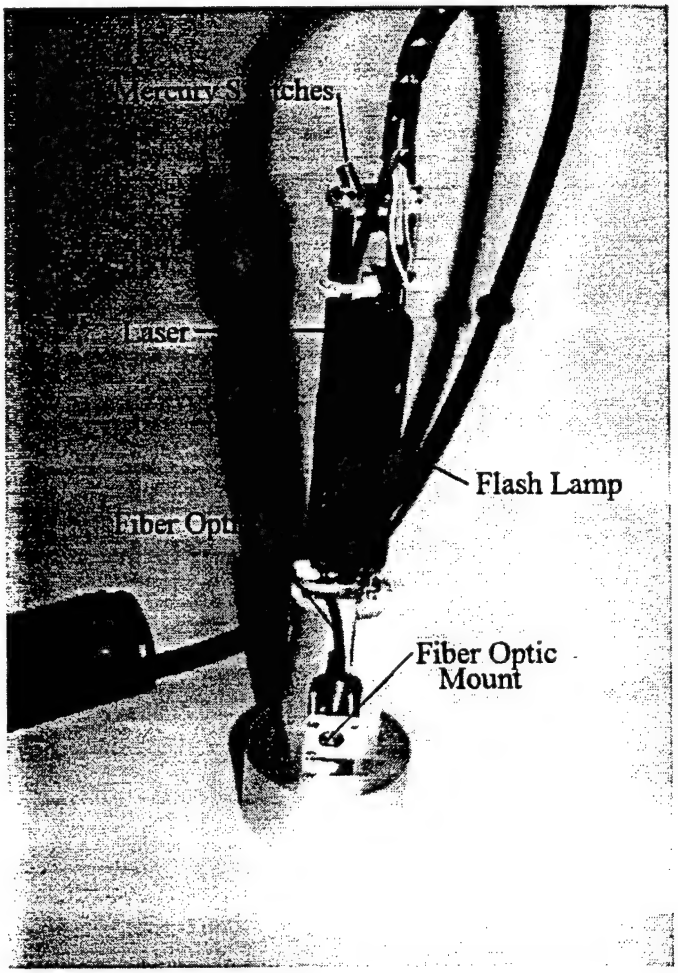

Figure 4.6 : Interior of Sample Probe

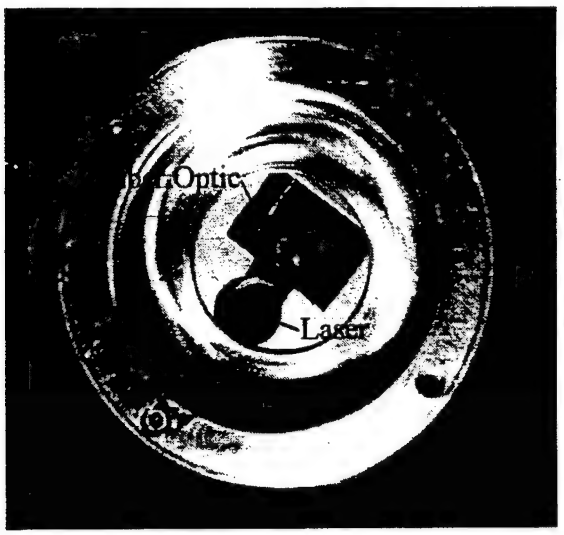

Figure 4.7 : End View of Sample Probe

Setting the laser power is accomplished as follows. The power should be set for the minimum setting that initiates a laser pulse. The first step is to place the sample probe on a surface such as lead or soil, and press the manual trigger button. An audible crack will occur if the laser power is high enough. If a crack is not heard, then a plasma was not created. Turn the laser power up or down depending on whether the crack was audible. Remember not to cycle the laser more than once every two seconds or so. The setting necessary for the laser when it left ADA Technologies was 7. A setting higher than necessary may cause double pulses, and wear out the Q-switch of the laser.

4.2 General Notes on the HP200LX Palmtop Computer

The HP 200LX Palmtop computer is a hand-held DOS based PC. It is comparable in speed and processing power to the old AT class IBM PC. It has a series of internal programs that can be used for everything from communications to spreadsheets. To give a complete description of all this features is not possible in this manual. If the user cares to know more about the unit, a complete manual has been included. For the purposes of this instrument only a few key points need to be understood.

The first point is that the PCMCIA card installed in the unit is a 10 MB flashdisk, which the palmtop believes is the "A drive." If the flashdisk is in the unit when the system is re-booted, then the autoexec.bat and config.sys on the PCMCIA card will be executed. These have been set to start running the LIBS monitor software, and all the built-in HP programs will NOT be accessible. To re-boot the palmtop, the "CTRL" and "ALT" and "DEL" buttons must all be pressed at the same time. Simply turning the power on and off will NOT re-boot the system and force it to run the autoexec.bat file.

The flashdisk is NOT stacked. This was done for several reasons. The first reason is that more system memory is available to the palmtop if stacker is not running. The second reason is that the flashdisk can be put in any PC with a PCMCIA slot (all laptops) and files can be transferred easily without having to run the palmtop-PC communications

program. If the flashdisk is stacked, then stacker needs to be run on any PC that the flashdisk is put into. This means changing the autoexec and config files on those machines. The final reason is that the flashdisk has enough memory without being stacked.

If the user wants access to the HP built-in applications, then remove the flashdisk and re-boot ("CTRL" and "ALT" and "DEL"). This will run the autoexec.bat and use the config.sys on the internal "C drive." The introductory screen will appear. Press the blue "&..." key and the HP application manager will come up. From there the user has access to everything. You can NOT use the "C:>, DOS" program to exit to DOS and expect to run the LIBS program. This is because the HP applications manager will still be running and will use virtually all the memory. It is best just to put the flashdisk back in and re-boot. It is possible to hit "ALT A T" and then select the OK button to get to DOS without the application manager running. It should then be possible to run the LIBS software from the "A drive." The last helpful note on exploring all the built in application is that when the "ALT" key is pressed, a series of menus appears at the top of the screen. These menus usually have whatever is necessary. Beyond those simple tips, the user is asked to refer to the HP manual for help.

The following are listings of the autoexec.bat and config.sys files located on the "A drive" and the "C drive."

4.2.1 AUTOEXEC.BAT from the "A drive"

```
@echo off
Rem
Rem To customize DOS startup files, copy config.sys and
Rem autoexec.bat from the D drive to the C drive and
Rem edit the C drive versions to meet your needs.
Rem

Rem
Rem Set prompt, path, and select C drive.
Rem
prompt $p$g
path c:\;d:\;d:\bin;d:\dos
rem c:\

Rem
Rem Following assign enables referencing the plug-in card as
Rem drive E (in addition to A). Using E allows some programs
Rem to run which refuse to run from a drive that is normally
Rem associated with a floppy drive.
Rem
assign e:=a:
a:\
```

```
Rem
Rem Load the Card Installation Client TSR to provide support
Rem for PCMCIA modem cards.  If these cards will not be used,
Rem prefacing with Rem will save system RAM.
Rem
rem d:\bin\cic100 /gen 1

Rem
Rem Load the first LapLink Remote Access TSR as required by the
Rem Server application.  If the Server will not be used,
Rem prefacing with Rem will save system RAM.
Rem
rem call d:\bin\llras

Rem
Rem Following 200 command starts the System Manager which
Rem provides access to the built-in applications.
Rem
rem 200

apbanzcb
```

4.2.2 CONFIG.SYS from the "A drive"

```
BUFFERS=20
FILES=30
LASTDRIVE=J
rem DEVICE=C:\STACKER\STACKER.COM /P=0 A: B:
rem DEVICE=C:\MAXFLASH\TFFS.COM /DRIVE=A /SIZE=4096
```

4.2.3 AUTOEXEC.BAT from the "C drive"

```
@echo off
Rem
Rem To customize DOS startup files, copy config.sys and
Rem autoexec.bat from the D drive to the C drive and
Rem edit the C drive versions to meet your needs.
Rem

Rem
Rem Set prompt, path, and select C drive.
Rem
prompt $p$g
path c:\;d:\;d:\bin;d:\dos
c:\
```

```
Rem
Rem Following assign enables referencing the plug-in card as
Rem drive E (in addition to A). Using E allows some programs
Rem to run which refuse to run from a drive that is normally
Rem associated with a floppy drive.
Rem
assign e:=a:

Rem
Rem Load the Card Installation Client TSR to provide support
Rem for PCMCIA modem cards. If these cards will not be used,
Rem prefacing with Rem will save system RAM.
Rem
rem d:\bin\cic100 /gen 1

Rem
Rem Load the first LapLink Remote Access TSR as required by the
Rem Server application. If the Server will not be used,
Rem prefacing with Rem will save system RAM.
Rem
rem call d:\bin\llras

Rem
Rem Following 200 command starts the System Manager which
Rem provides access to the built-in applications.
Rem
200
```

4.2.4 CONFIG.SYS from the "C drive"

```
BUFFERS=20
FILES=30
LASTDRIVE=J
rem DEVICE=C:\STACKER\STACKER.COM /P=0 A: B:
rem DEVICE=C:\MAXFLASH\TFFS.COM /DRIVE=A /SIZE=4096
```

4.3 CCDOPS Software

CCDOPS is a program that comes with the CCD camera from Santa Barbara Instruments. It is a full featured application with can run the CCD in either a two dimensional mode or the spectrographic signal dimensional mode. For this application, the spectrographic mode should be used. The software and manual have been included with this instrument. This software allows the user to more fully explore the capabilities of this instrument, without being limited to the custom application for measuring lead. The CCDOPS software is a research tool, and it is expected that anyone who desires to use it can quickly

discern from the manual how to operate it. A few notes follow on the exact configuration necessary for operating this particular instrument.

Do not cycle the laser faster than one hertz. Slower is preferable. This is set under the "Spect" "Acquire" menu. The CCD will provide the trigger for the laser at the update rate that you set. See the CCDOPS manual for more information on external triggers.

Under "Camera" "Set-up" choose "XH" for binning all the vertical elements to make the highest resolution spectrum. See the CCDOPS manual for more information.

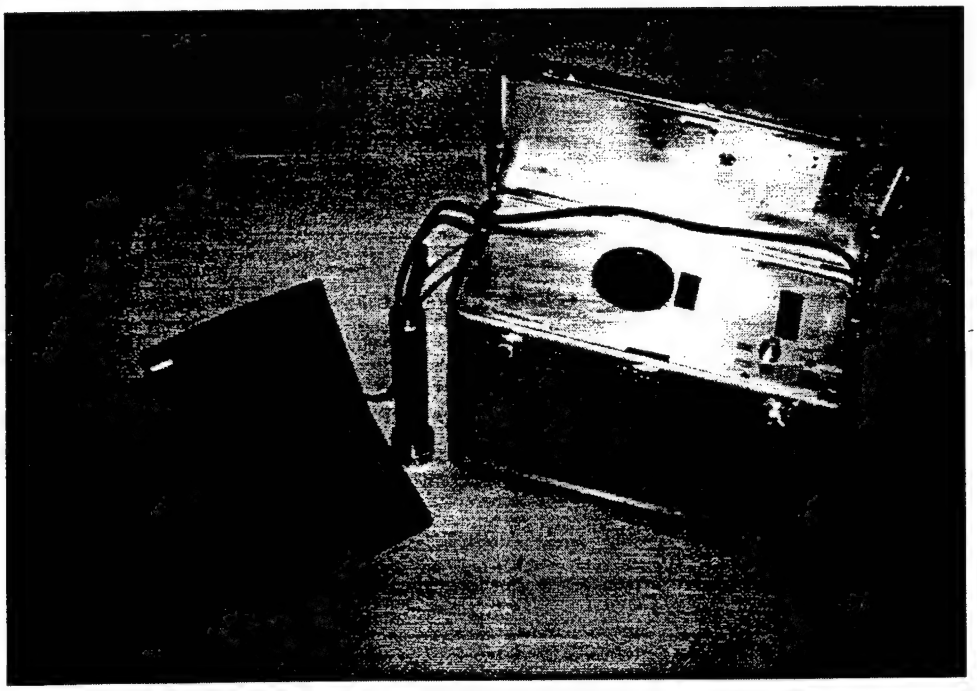

Figure 4.8 : LIBS Instrument Using a Laptop and CCDOPS

4.4 Operation Software

Two programs exists for use with this Pb LIBS monitor. These programs are simple and not completely free of bugs. In Phase II, these programs will be greatly enhanced and debugged. The first program that must be used is the calibration program, "apbcalcb.exe". This program steps the user through calibrating the instrument. This program has been run on this instrument using the calibration samples included with the instrument. The ROI (region of interest) table used for calibration is titled ADA2. Five laser pulses per calibration point were used. The sample was moved between each laser pulse.

The second program is the sample analysis program "apbanzcb.exe". This program uses the calibration file created using the calibration program "apbcalcb.exe" to analyze a sample for lead content. To stop the program at any point type "CTRL" and "BREAK" (the "BREAK" key is also labeled "MENU"). You can also follow the menus to the natural stopping point. If the system does not seem to be operating properly, try re-booting. Occasionally, the program will crash and leave the system variables in an improper state. These system variables can only be cleared through re-booting.

Remember the system does not re-boot when you turn the power on and off, you must use "CTRL" and "ALT" and "DEL" at the same time to re-boot.

For research and evaluation of the instrument's capabilities, the CCDOPS software from Santa Barbara Instruments is much more valuable.

5. Maintenance

Since this is a first generation proof-of-concept instrument, a general maintenance list and schedule does not exist. A few obvious notes have been included as a starting point. The best approach for maintenance at this point is to understand how the instrument operates and look for any change in performance.

5.1 General

The user should check to make sure the laser optics and the fiber optic tip are not becoming covered with debris. Use the same care on these optic components as on other quality optics (like photographic lenses).

5.2 Battery Charger

Included with this instrument was a spare lead acid battery and a battery charger. One battery can be used while the other battery in being charged. Alternatively, the battery charger can be hooked up directly to the battery in the enclosure overnight for charging. In both cases, the battery should be electrically disconnected from the rest of the instrument.

5.3 Parts List

The next five pages include all the parts in this LIBS monitor. The first list is broken down by sub-assembly including 1) Monitor Unit, 2) Sample Probe, 3) Power Assembly, and 4) Control Unit. The distinctions should be obvious. The second list has essentially the same information, except it gives costs and vendors. The final list is a list of vendors that parts were purchased from for this project. It includes complete mailing addresses and phone numbers. If parts need to be replaced on this prototype instrument, the following pages should be a great help in finding them.

Kit List for 1 units of PB MONITOR

Kit Qty	Inv Count	P/N	On Assy	Type	Mfr P/N	Mfr	Vend P/N	Vend Desc	Title	Detail
1	0	FLASHCARD	CONTROL UNIT	PS			F1013A	10MB/20MB comp Flashcard	10MB\20MB compressed Flashcard	Memory for HP Palmtop Computer
1	0	HP SERIAL	CONTROL UNIT	PS			2793	Serial Cable	Serial Cable for HP 100/200 LX	HP 10 pin HP 100/200 to 9 pin Serial Cable
1	0	HP-200LX	CONTROL UNIT	PS			HP200LX2MB	HP 200LX Palmtop	HP 200 LX Palmptop PC	Get with 2 Meg of RAM
1	0	10PA032	MONITOR UNIT	PS			10PA032	Push Button Switch	Push Button Switch, recessed	SPST off-on, Red, 1A 125V
1	0	11-115	MONITOR UNIT	PS			11-115		Grating for MonoSpec 18	Ruled grating, 2400g/mm, 250nm blaze
1	0	12-527	MONITOR UNIT	PS					150 Micron Wide Slit, 18 mm High	Slit for MonoSpec 18 from Jarrel Ash
4	0	132X-SI	MONITOR UNIT	PS	132X-SI				Centurion Case	Enclosure for Phase I LIBS Pb Monitor
1	0	82-479	MONITOR UNIT	PS			82-479		Monochromator/Spectrometer 18	Spectrograph Version for Pb Monitor
1	0	FIRE CONTROLLER	MONITOR UNIT	PS	Fire Controller	Kigre, Inc	Fire Controller		Fire Controller	for use w/ MK-1020 OEM P.S.
1	0	MK-1020	MONITOR UNIT	PS	MK-1020	Kigre, Inc	MK-1020		OEM Power Supply	for use w/ MK-480 laser resonator
1	0	MK-480T	MONITOR UNIT	PS	MK-480T	Kigre, Inc	Mk-480T		Trigger Module for MK-480 Laser	2 meter in length cable
1	0	ROM FOR CCD	MONITOR UNIT	PS			Spec ROM	ROM and Spec Software	ROM and Spectroscopy Software	ROM and Spec Software for CCD ST=6
1	0	ST-6V CCD	MONITOR UNIT	PS					Camera System w/ Ouartz Optics	
1	0	163-4025	POWER ASSEMBLY	PS			163-4025	DC Power Jack	DC Power Jack	2.5mm, metal

Kit List for 1 units of PB MONITOR

Kit Qty	Inv Count	P/N	On Assy	Type	Mfr P/N	Mfr	Vend P/N	Vend Desc	Title	Detail
1	0	171-3215	POWER ASSEMBLY	PS			171-3215	DC Power Plug	DC Power Plug, 2.1mm	
1	0	547-PS12120	POWER ASSEMBLY	PS			547-PS12120	Lead Acid Battery	Rechargeable Sealed Lead Acid Battery	12VDC, 9lbs
1	0	547-PSC124000A	POWER ASSEMBLY	PS			547-PSC124000A	Battery Charger for Lead Acid	Battery Charger for Lead Acid Batteries	12VDC, 4.00A, metal
3	0	107-1000	PROBE ASSEMBLY	PS			107-1000	Mercury tilt-over switch	Mercury Tilt-over Switch	50VA, 250VAC, Max Current 0.05A, Res=200mOhm
1	0	7432K22	PROBE ASSEMBLY	PS			7432K22	Helical Bundling Wrap	Helical Bundling Wrap	3/8" Black Polyethylene, 50 foot
1	0	FIBER OPTIC CABLE	PROBE ASSEMBLY	PS	Custom1	C Technologies	Custom	2m Custom Fiber Optic Cable	Fiber Optic Cable	Custom, 2m long, 200 micron core, round / linear
1	0	MK-480	PROBE ASSEMBLY	PS	MK-480	Kigre, Inc	MK-480		Laser Resonator Assembly	

Purchase List (bom) for 1 units of PB MONITOR

Date Printed 12/2/96

P/N	Title	Detail	Rev	Type	Cur Cost	Total Qty	Ext Cost	Inv Avail	Short Qty	Short Cost	Vendor
107-1000	Mercury Tilt-over Switch	50VA, 250VAC, Max Current 0.05A, Res=200mOhm		PS	$7.500	3	$22.50	0	3	$22.50	Mouser Electronics
10PA032	Push Button Switch, recessed	SPST off-on, Red, 1A 125V		PS	$2.760	1	$2.76	0	1	$2.76	Mouser Electronics
11-115	Grating for MonoSpec 18	Ruled grating, 2400g/mm, 250nm blaze		PS	$460.000	1	$460.00	0	1	$460.00	Scientific Measurement Systems, Inc.
12-527	150 Micron Wide Slit, 18 mm High	Slit for MonoSpec 18 from Jarrel Ash		PS	$90.000	1	$90.00	0	1	$90.00	Scientific Measurement Systems, Inc.
132X-SI	Centurion Case	Enclosure for Phase I LIBS Pb Monitor		PS	$445.920	4	$1,783.68	0	4	$1,783.68	Zero Enclosures
163-4025	DC Power Jack	2.5mm, metal		PS	$2.760	1	$2.76	0	1	$2.76	Mouser Electronics
171-3215	DC Power Plug, 2.1mm			PS	$0.980	1	$0.98	0	1	$0.98	Mouser Electronics
547-PS12120	Rechargeable Sealed Lead Acid Battery	12VDC, 9lbs		PS	$41.400	1	$41.40	0	1	$41.40	Mouser Electronics
547-PSC124000A	Battery Charger for Lead Acid Batteries	12VDC, 4.00A, metal		PS	$107.700	1	$107.70	0	1	$107.70	Mouser Electronics
7432K22	Helical Bundling Wrap	3/8" Black Polyethylene, 50 foot		PS	$9.440	1	$9.44	0	1	$9.44	McMaster-Carr
82-479	Monochromator/Spectrometer 18	Spectrograph Version for Pb Monitor		PS	$1,460.000	1	$1,460.00	0	1	$1,460.00	Scientific Measurement Systems, Inc.
FIBER OPTIC CABLE	Fiber Optic Cable	Custom, 2m long, 200 micron core, round / linear	1	PS	$625.000	1	$625.00	0	1	$625.00	C Technologies
FIRE CONTROLLER	Fire Controller	for use w/ MK-1020 OEM P.S.		PS	$200.000	1	$200.00	0	1	$200.00	Kigre Inc.
FLASHCARD	10MB\20MB compressed Flashcard	Memory for HP Palmtop Computer		PS	$579.000	1	$579.00	0	1	$579.00	EduCALC

Selected Primary Vendors

Name	Address 1	Address 2	CityStateZip	Ctry	Phone2	Phone1	Fax	Our Acct#
ADA Technologies, Inc.	304 Inverness Way S., Suite 365		Englewood, CO	80112		303-792-5615	303-792-5633	
Arrow Star	3-1 Park Plaza	Dept. T	Glen Head, NY 11545		516-484-3100	800-645-2833	800-835-2292	
C Technologies			,			201-984-9092	201-984-9092	
EduCALC	27953 Cabot Road		Laguna Niguel, CA,	92677		800-677-7001	714-582-1445	
Kigre Inc.	100 Marshland Road		Hilton Head Island, SC	29926		803-681-5800	803-681-4559	
McMaster-Carr	P.O. Box 4355		Chicago, IL 60680-4355			708-833-0300	708-834-9427	
Mouser Electronics	2401 Hy 287 N.		Mansfield, TX 76063-4827			800-346-6873		
Santa Barbara Instruments Group	1482 East Valley Road	Suite 1601	,			805-969-1851	805-969-4069	
Scientific Measurement Systems, Inc.	2527 Foresight Circle		Grand Junction, CO 81505-1007		970-241-3308	800-747-3308	970-241-6618	
Zero Enclosures	500 W. 200 N.		Salt Lake, UT	84054		800-298-5900		

Purchase List (bom) for 1 units of PB MONITOR

P/N	Title	Detail	Rev	Type	Cur Cost	Total Qty	Ext Cost	Inv Avail	Short Qty	Short Cost	Vendor
HP SERIAL	Serial Cable for HP 100/200 LX	HP 10 pin HP 100/200 to 9 pin Serial Cable		PS	$22.950	1	$22.95	0	1	$22.95	EduCALC
HP-200LX	HP 200 LX Palmptop PC	Get with 2 Meg of RAM		PS	$679.000	1	$679.00	0	1	$679.00	EduCALC
MK-1020	OEM Power Supply	for use w/ MK-480 laser resonator		PS	$1,500.000	1	$1,500.00	0	1	$1,500.00	Kigre Inc.
MK-480	Laser Resonator Assembly		1	PS	$4,260.000	1	$4,260.00	0	1	$4,260.00	Kigre Inc.
MK-480T	Trigger Module for MK-480 Laser	2 meter in length cable		PS	$500.000	1	$500.00	0	1	$500.00	Kigre Inc.
ROM FOR CCD	ROM and Spectroscopy Software	ROM and Spec Software for CCD ST=6		PS	$360.000	1	$360.00	0	1	$360.00	Santa Barbara Instruments Group
ST-6V CCD	Camera System w/ Ouartz Optics			PS	$2,950.000	1	$2,950.00	0	1	$2,950.00	Santa Barbara Instruments Group